NOTES ON THE CENTRAL CONTROL SYSTEM

F. C. Shoemaker

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A series of meetings were held in November, 1968, to initiate the specification of the control system. Participants included A. Albert, M. Awschalom, R. Billinge, T. Collins, A. Maschke, Q. Kerns, F. Shoemaker, and D. Young. The emphasis in these meetings was on the interaction between the several subaccelerators and other major systems. Most of the time was spent exploring the nature of the interactions, so that the mechanism of the controls required did not receive much attention. The schedule was intensive to provide continuity and was broken off when it became clear that further discussion should be based on further study in the individual sections. There were a few decisions made during the meetings which were confirmed in a review in the first of a new series of controls meetings now in progress.

Master Clock

This should be a main control room (MCR) function. The clock should run phase locked to the 60-Hz mains, with averaging circuits to improve the short-term frequency stability, e.g., to filter out the phase noise on the line. For simplicity, it was agreed that the prime timing pulses, upon which the main-ring magnet cycle would be based, occur at the time the booster magnet is at its minimum field. Implied is a restriction that changes in the lengths of each of the portions of the main-ring cycle would only be made in multiples of one booster period. A further subdivision of the cycle is needed, as many circuits which must be precisely timed from the clock must receive their initiating pulses at times between prime timing pulses. These interpolating pulses, spaced about 100 microseconds apart, should be generated in the MCR for economy and precision coordination of time between various subsystems. It would be desirable for all of master clock pulses to be transmitted on a single line, with "boxes" available which would allow one to select, unambiguously, the needed timing pulses for any given application. The "landmark" times in the main-ring cycle should be included. Such boxes would be of great value to experimenters as well as to accelerator subsystems and should be designed to be mass-produced.

Enable Logic

Many accelerator subsystems may be timed from the Master Clock. Examples include the booster magnet power supply, the linac rf pulser, the ion source pulser, the main-ring magnet power supplies, etc. Many other systems must be locally timed. Examples of this class are injection into the booster, which must be timed from the booster magnet (momentum match with the linac) and beam transfer between the booster and main ring. To establish the master accelerator cycle, the various components must be provided with information as to the status of other components. A master "enable" system, based in the MCR, would fill this need, and, in addition, easily provide for proper inhibition of acceleration of unwanted protons should a fault develop in any part of the system. These enables should consist of levels which are combined with timing pulses (in "and" gates) at the location of the controlled device. The system should be hard wired, as it should operate in real time with a minimum of delay. The "enable" levels should be generated in the MCR from "enable" levels which have been transmitted to the MCR from the various subsystems, signifying their readiness to receive beam, and from the master clock. The MCR equipment required is simply a small rack full of dc coupled "and" gates. If ground-loop problems arise, it is possible that the enable levels will have to be transmitted in the form of start-stop pulse pairs, transformer coupled.

Beam Abort System

A discussion which grew from a consideration of some aspects of the enable logic, and the feasibility of a fast beam switch in the 10-BeV transfer line, resulted in the realization that each subaccelerator must have a way of disposing of unwanted beam. This is liable to be a formidable system, as it is clear that the main-ring abort system must be capable of not only handling an extensive sequence of 15-BeV pulses while injection is optimized, but it must also be capable of absorbing, without damage, a large number of 200-BeV pulses while the extraction system is being adjusted. The abort system must be constantly ready, as it would be triggered by a component failure in either the main ring or the extraction beam line. The booster must have an abort system to absorb accelerated beam if its extraction system is incapable of taking care of it. It is possible that the amount of absorbed radiation in the abort beam dumps may be reduced for some (certainly not all) types of operation, by decelerating unwanted beam to as low an energy as possible, before triggering the abort.

Intensity Adjustment

There was agreement that the demands on the accelerator will mean operation with a wide range of total accelerated beam intensity, and that it should be possible to change the intensity on short notice. There was no real light shed on the optimum way of regulating the intensity, consistent with the policy of avoiding acceleration of unwanted beam. In a high intensity accelerator, nearly all aspects of the operation are intensity dependent, especially the resonant extraction process. More thought and much work clearly is needed before this problem is solved.

Injection Regime

The discussion of the enable system also resulted in a reexamination of the number of booster pulses versus the duration of the main-ring injection period. Another consideration was the cost of the main-ring fast kicker for injection, which would be lowered substantially by an increase in the space between circulating bunches in the main ring. We agreed that, at least for initial operation, the booster would inject 12 shots with 10 empty buckets between shots in the main ring. This will also allow the main-ring field to stabilize before injection from the linac into the booster for the first shot of each main-ring cycle.